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Benthic foraminifera and calcareous algae from the Anisian-Norian succession in the Tatras (Poland and Slovakia): New data from High-Tatric and Krížna units

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Abstract. The paper is focused on new micropalaeontological data from the Triassic succession of Krížna and High-Tatric units in the Tatra Mts. Benthic foraminifera species were determined from the Anisian-Norian succession of the Krížna Unit and the Anisian succession of the High-Tatric Unit. In the later, calcareous algae species were also found. In mentioned Triassic successions, most of genera were described for the first time, while the others were found in new locations. A few of them belong to index fossils. Based on the assemblage containing calcareous algae *Oligoporella* species, characteristic for the *Oligoporella pilosa – Phisoporella pauciforata* zone, as well as the foraminifera *Meandrospira dinarica*, and the presence of *Diplopora annulatissima*, the age of the upper part of the Stoły pod Ciemniakiem section (High-Tatric Unit) is most probably Lower Illyrian. The establishment of the foraminifera species *Pilamminella semiplana, Glomospirella triphonensis* and *Nodosaria skyphica*, within the limestone of the Łysanki section and accompanying species *Ophthalmidium* cf. *exiguum, Hoyenella* gr. *sinensis*, *Agathammina* sp. and *Gaudryina* sp. from Żleb pod Czerwieniec and Skoruśniak sections (Krížna Unit): suggest early Anisian age. Ladinian age is indicated by the *Turriglomina mesotriasica – Glomospirella kuthani/gemerica – Aulotortus gaschei praegaschei* assemblage present in the dolostones of the Skupniów Upłaz and Hlúpy sections (Krížna Unit). The assemblage from dolostones of the Żleb pod Czerwoną Przełęcz (Krížna Unit) includes *?Triasina hantkeni* species, which is a zone marker for the upper Norian (Sevatian) to Rhaetian succession.

Keywords: foraminifera, algae, stratigraphy, Triassic, Tatricum, Fatricum, Western Carpathians

INTRODUCTION

The paper is focused on new micropalaeontological data from several sections of the Anisian-Norian succession of Krížna and High-Tatric units in the Tatra Mts (southern Poland, northern Slovakia). A few hundred metres complex of sedimentary rocks mentioned above contain rare index fossils. Genera described below belong to benthic foraminifera and calcareous algae. Some of described taxa are reported for the first time from mentioned succesion, whereas the others are found in further locations.

Presented data are a supplement of earlier investigations on benthic foraminifers and calcareous algae from Triassic of Krížna and High-Tatric units in the Tatra Mountains (Kotański, 1963, 1967, 1979a; Bac and Grochocka, 1965; Piotrowski, 1965; Bełka and Gaździcki, 1976; Gaździcki and Lipiec, 1995). Some of the identified taxa enable better biostratigraphical resolution of mentioned deposits.

GEOLOGICAL SETTING

The Tatra Mts are composed of the Variscan crystalline basement, its sedimentary cover and overthrusted nappes built of Mesozoic rocks (Fig. 1). High-Tatric Unit consists of autochthonous (or paraautochthonous) cover of crystalline rocks and two allochthonous units (the lower Czerwone Wierchy nappe and the upper Giewont nappe; Kotański, 1961, 1979b; Passendorfer, 1961; Dumont et al., 1996). High-Tatric Unit is overlaid by two Sub-Tatric nappes: the lower Krížna nappe and the upper Choč nappe. The Krížna nappe is composed of several partial nappes and tectonic scales (Goetel and Sokołowski, 1929; Sokołowski, 1948; Andrusov, 1959; Guzik and Kotański, 1963; Kotański, 1963; Bac, 1971).

Deposits of High-Tatric, Krížna and Choč were cumulated in Tatricum, Fatricum and Hronicum basins respectively (Andrusov et al., 1973; Kotański, 1979b; Michalík and Gaździcki, 1980).

The tectonic units are built of sedimentary rocks of Lower Triassic-Lower Turonian (High-Tatric Unit), Lower Triassic-Albian (Krížna Unit) and Middle Triassic to Bajocian (Choč Unit; Wieczorek, 2000; Uchman, 2004).

During Triassic time, Tatricum and Fatricum basins were located in the northern part of Carpathian branch of Western Tethys Ocean (Meliata-Hallstatt Ocean; Kozur, 1991; Michalík, 1994; Wieczorek, 2000). The palaeogeographical vicinity of both basins caused similar facies development during Triassic time. Diversification of sedimentary environments took place only in the Rhaetian as a result of tectonic disintegration of southern Palaeoeuropean shelf (Michalík, 1993, 1994).

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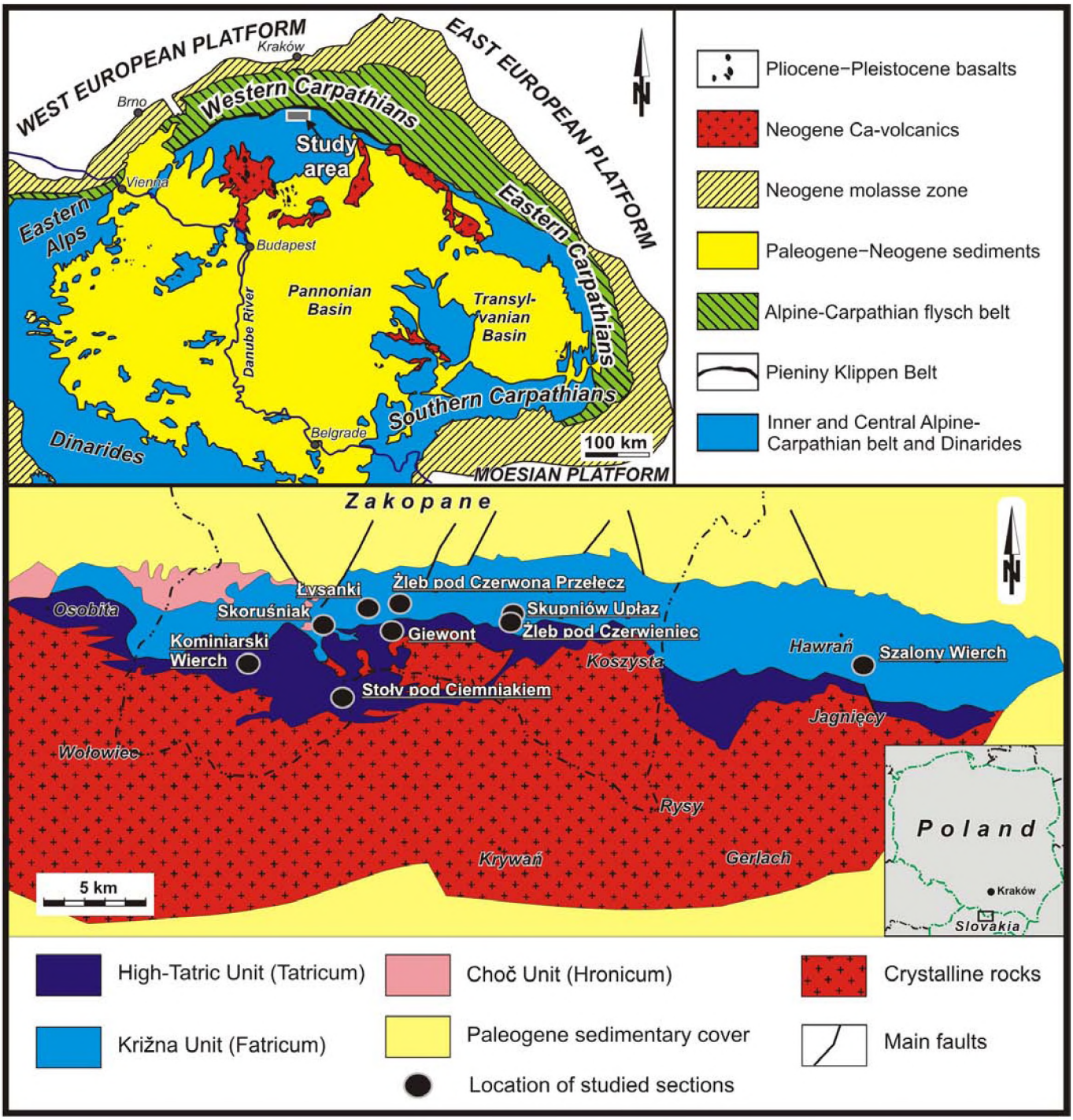

Fig. 1. *Location of the study area. a) Location of the Tatra Mountains in the geological sketch-map of the Alpine-Carpathian-Pannonian orogenic belt (after Jurewicz, 2005; modified; b) Location of the studied sections in the tectonic sketch map of the Tatra Mountains (after Bac-Moszaszwili et al., 1979; modified).*

Middle Triassic successions of Tatricum and Fatricum units are underlied by the upper Olenekian (Campilian) dolostones alternately with dark marly limestones (partly dedolostones) and dolomitic mudstones of Myophoria beds (Kotański, 1956a, 1963; Jaglarz and Rychliński, 2010). The above mentioned series represent hypersaline deposits of marginal zone of restricted carbonate ramp (Kotański, 1979a; Rychliński and Jaglarz, 2010). Anisian and Ladinian of the High-Tatric Unit and Anisian of the Krížna Unit is developed as black limestones intercalated with grey dolostones, while Ladinian of the Krížna Unit is dominated by dolostones.

The set of sedimentary features indicates that the Middle Triassic succession of Tatricum and Fatricum was deposited on restricted carbonate ramp under relatively hot and arid climate conditions. Isolated basins with facies typical for low energy environments were exposed to influence of subtropical storms (Jaglarz and Szulc, 2003; Rychliński and Szulc, 2005; Jaglarz and Uchman, 2010).

The basins were emerged at the end of Ladinian (Rychliński and Szulc, 2005; Rychliński, 2008; Jaglarz, 2010). The Carnian-Norian succession of Tatricum and Fatricum units is developed as two facies of the Carpathian Keuper: sandstone-mudstone

and dolostone-dolomitic mudstone (Turnau-Morawska, 1953; Kotański, 1956b, 1959a, b, 1979a). Siliciclastic deposits represent fluvial facies, while dolostone-dolomitic mudstone facies were deposited in marginal marine environment heavily influenced by continent (Al-Juboury and Ďurovič, 1996; Rychliński, 2008; Jaglarz, 2010).

Middle Triassic succession of High-Tatric and Krížna units is generally characterized by a scarcity of index fossils. Benthic foraminifera, calcareous algae, crinoids, brachiopods, bivalves and gastropods date on Anisian age the lower part of the Middle Triassic succession from the High-Tatric Unit (Rabowski, 1931; Lefeld, 1958; Bac and Grochocka, 1965; Piotrowski, 1965; Niedźwiedzki and Salamon, 2006; Rychliński et al., 2008), whereas the upper part of disscussed rock complex (Ladinian) is not palaeontologically substantiated (Kotański, 1979a). In Krížna Unit, Anisian part of the Middle Triassic succession is dated by calcareous algae, crinoids and brachiopods (Uhlig, 1897; Kotański, 1958; 1963, 1965, 1967, 1973; Niedźwiedzki and Salamon, 2006), whereas the Ladinian part is determined basing on calcareous algae (Kotański, 1963, 1965, 1967).

Norian age of Carpathian Keuper succession of the Krížna Unit was indicated by spores, pollens and benthic foraminifera (Gaździcki, 1983; Fijałkowska and Uchman, 1993), whereas Carpathian Keuper of the High-Tatric Unit is not palaeontologically dated.

PREVIOUS STUDIES ON BENTHIC FORAMINIFERA AND CALCAREOUS ALGAE FROM THE ANISIAN-NORIAN SUCCESSION IN THE TATRA MTS.

Benthic foraminifera

For many years sedimentary rocks of the Tatra Mts have been subject of micropalaeontological investigations. The first article dedicated to foraminifera study from the Tatra Mts was published by O. Saxl (in: Goetel, 1917) and was devoted to the Upper Triassic foraminifera.

The Middle Triassic foraminifera from the High-Tatric Unit were described by Bełka and Gaździcki (1976). The assemblage of Anisian foraminifera includes stratigraphycally important forms. The species *Ammodiscus incertus* (d'Orbigny), *Glomospira densa* (Pantić), *Glomospirella grandis* (Salaj), *G. triphonensis* (Baud, Zaninetti and Broennimann) and five genera with open nomenclature have been specified at the Kominiarski Wierch section. This association indicated the latest Early Anisian, through Early Illyrian age.

Anisian foraminifera from the Ogarle-Opalone scale (High-Tatric Unit, Giewont nappe) were described by Gaździcki and Lipiec (1995). The foraminifera recognized at the Ogarle section in the Kondratowa Valley include stratigraphically important taxa such as: *Glomospira densa* Pantić, *Glomospirella grandis* (Salaj) and *Meandrospira dinarica* Kochansky-Dévide and Pantić. According to the authors, their stratigraphic range coincides with the *Glomospira densa* Zone (Bithynian–Illyrian).

Dolostones from uppermost part of the Carpathians Keuper succession from the Lejowa Valley section (Krížna Unit) contains *Agathammina austroalpina* Kristan Tollmann and Tollmann (Gaździcki, 1983).

The stratigraphically important foraminifera assemblages from the Choč nappe in the Tatra Mts were described for the first time by Gaździcki and Zawidzka (1973). The association found in limestones from the Wielkie Koryciska Valley includes following species: *Ammobaculites* cf. *radstadtensis* Kristan-Tollmann, *Calcitornella*? sp., *Hemigordius*? *chialingchaingensis* (Ho), *Trochammina almtalensis* Koehn-Zaninetti, *Turritellella mesotriassica* Koehn-Zaninetti. This association indicates Upper Anisisan (Illyrian) age. Well preserved few foraminifera of Anisian age (such as: *Glomospirella shengi* Ho, *Trochamminoides pusillus* Ho, *Trochammina* cf. *pulvila* Crespin and Parr, *Pachyphloides klebelsbergi* (Oberhauser), *Geinitzinita oberhauseri* Sellier, Civrieux and Dessauvagie, *Pseudonodosaria simpsonensis* (Tappan), *Nododsaria spiculata* Crespin, *N. raggatti* Crespin, *N. ordinata* Trifonova, *Dentalina* cf. *turgoidea* Kristan-Tollmann, *Lenticulina (Vaginulinopsis) cryptospira* (Paalzow), *Marginulina solida* Terquem, *Lenticulina (Astacolus) karnica* (Oberhauser) were described by Alexandrowicz and Szewczyk (1981) from marls and limestones of the Wielkie Koryciska Valley (Choč nappe). However, these assemblages (dominated by representatives of the *Nodosariidae* family) are not sufficient to define biostratigraphic zones.

Calcareous algae

Calcareous algae, such as *Physoporella pauciforata* (Gümbel), *P. prealpina* Pia, *P. dissita* (Gümbel), *P. minutula* (Gümbel), *Diplopora annulatissima* Pia, *D. helvetica* Pia, *D. hexaster* Pia, *Macroporella* sp., *Griphoporella* sp., and *Poikiloporella* sp. were found within Middle Triassic succession of the High-Tatric Unit in Kominiarski Wierch and Kościeliska Valley localities and indicated the Pelsonian-Illyrian age (Bac and Grochocka, 1965; Piotrowski, 1965; Kotański, 1967, 1979a).

Calcareous algae *Physoporella pauciforata* (Gümbel), *Physoporella prealpina* Pia and *Physoporella dissita* (Gümbel) of Pelsonian-Illyrian age were described by Kotański (1965, 1967, 1973) from Wolarnia scale and borehole of Zakopane IG-1 (Krížna Unit). The same author (Kotański (1963, 1967) described *Diplopora annulata* var. *annulata* (Schafhäutl), *Diplopora annulata* var. *dolomitica* (Schafhäutl), *Diplopora annulatissima* Pia, *D. uniserialis* (Pia), *Physoporella dinarica*, *Macroporella* sp. and *Teutloporella* sp. from many localities at the Krížna Unit, which indicated the Fassanian age.

Based on assemblage of calcareous algae with *Physoporella pauciforata* (Gümbel), *P. prealpina* Pia, *P.* aff. *dissita* (Gümbel) and *Diplopora annulatissima* Pia the age of diplopore and oncolitic dolostones from the Choč nappe was determined as the Late Anisian (Kotański, 1965). Early Ladinian age of Wetterstein type dolostones from the Koryciska scale (Choč nappe) was concluded on the basis of the presence of calcareous algae with *Teutloporella herculea* (Stoppani), *T.* cf. *aequalis* (Gümbel), *T. tenuis* Pia, *Diplopora annulata* var. *dolomitica* (Schafhäutl), *Macroporella* sp., *Griphoporella* sp., *Acicularia* sp. and *Clypeina* sp. (Kotański, 1967, 1973).

MATERIALS AND METHODS

About five hundred thin sections of the Triassic carbonate rocks from High-Tatric and Krížna units were analysed. Benthic foraminifera and/or calcareous algae were found in a dozen of rock samples. Foraminifera were examined in limestones and dolostones from Stoły pod Ciemniakiem, Giewont and

Kominiarski Wierch sections (High-Tatric Unit), as well as in Łysanki, Skoruśniak, Żleb pod Czerwieniec, Hlúpy, Skupniów Upłaz and Żleb pod Czerwoną Przełęcz sections (Krížna Unit). Calcareous algae were identified in limestones of the Stoły pod Ciemniakiem section (High-Tatric Unit).

DESCRIPTION OF DETERMINED SPECIES

Benthic foraminifera

Agathammina austroalpina Kristan-Tollmann and Tollman, 1963 (Pl. I, Figs 17-18).

Sections: Skupniów Upłaz (Krížna Unit; Fig. 2A), Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3)

Biostratigraphical distribution: Late Anisian-Rhaetian (Koehn-Zaninetti, 1969).

Geographical distribution: Western Tethys: Gurktaler Alps (Kristan-Tollmann and Tolmann, 1963); Region de L'Almtal, Haute-Autriche (Koehn-Zaninetti, 1969); Trento, Northern Italy (Premoli Silva, 1971); Elika Formation, Central Albourz, Northern Iran (Zaninetti et al., 1972c); Northwest Caucasus and Cis-Caucasus (Efimova, 1974); Turkey, Austrian Alps and China (Zaninetti, 1976); Central and Southern Tunisian Atlasic Range (Kamoun et al., 1997); Pinarbasi area, eastern Taurus, Turkey (Altiner and Zaninetti, 1981); West Carpathians (Salaj et al., 1967, 1983); Slovakian and Polish Carpathians, among other from Krížna and Choč units of the Tatra Mts. (Gaździcki and Zawidzka, 1973; Gaździcki, 1974, 1983); Northern Apennines (Ciarapica et al.,1987); Transdanubian Range (Oravecz-Scheffer, 1987); Lienzer Dolomiten, Eastern Tirol, Austria (Blau and Schmidt, 1990); Corsica, Balagne Autochthon (Peybernès et al., 1991); Northeastern Iberian Peninsula (Arnal et al., 2002); Kalkwendel range, Northern Calcareous Alps, Austria (Nittel, 2006; SW Cyprus (Martini et al., 2009). Eastern Tethys: Yushu Region, Qinghai, Northwest China (He and Wang, 1990); Sambosan Accretionary Complex, southern Kyushu, Japan (Chablais et al., 2010a); Southwestern Japan (Chablais et al., 2010b, 2011).

Agathammina? iranica Zaninetti, Brönnimann, Bozorgnia and Huber, 1972c (Pl. I, Fig.16).

Section: Stoły pod Ciemniakiem (High-Tatric Unit; Fig. 4B).

Biostratigraphical distribution: Middle-Late Anisian (Bucur et al., 1997) - Norian-Raethian Zaninetti (1976).

Geographical distribution: Elika Formation, Iran (Zaninetti et al., 1972c); Turkey, Austrian Alps and China (Zaninetti, 1976); Pinarbasi, Taurus oriental, Turkey (Altiner and Zaninetti, 1981); NE of Oravita, Southern Carpathians, Rumania (Bucur et al., 1997); Southwestern Japan (Chablais et al., 2011).

Aulotortus ex. gr. *praegaschei* (Koehn-Zaninetti, 1969) (Pl. I, Figs 2-4).

Section: Skupniów Upłaz (Krížna Unit; Fig. 2A); Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3).

Biostratigraphical distribution: Ladinian-Carnian (Zaninetti, 1976) - Norian-Rhaetian (Kamoun et al., 1994).

Geographical distribution: Almtal region, Austria (Koehn-Zaninetti and Brönnimann, 1968; Koehn-Zaninetti, 1969); Turkey, Austrian Alps and China (Zaninetti, 1976); Taurus Mts., Turkey (Dager, 1975); Inner Carpathians (Salaj et al., 1983); Yushu region, Qinghai, Northwest China (He and Wang, 1990); Corsica, France (Peybernès et al., 1991); Baise Basin, Guangxi, China (He and Cai, 1991); Bulgaria (Trifonova, 1993); southern part of Tunisia (Peybernès et al., 1993); Fkirine Formation, Central Tunisia (Kamoun et al. 1994); Central and Southern Tunisian Atlasic Range (Kamoun et al., 1997); Arabian shelf in the northern United Arab Emirates (Maurer et al., 2008).

Comment: Ciarapica and Zaninetti (1984, 1985) made a revision of the type material and listed some foraminifera as synonym with *Aulotortus friedli*. However, *Aulotortus gaschei praegaschei* were showned as separate species with synonyms but not conspeciffic with *A. friedli*.

Aulotortus ex. gr. *?sinuosus* Weynschenk, 1956 (Pl. I, Fig. 4).

Section: Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3).

Biostratigraphical distribution: Ladinian (Zaninetti, 1976) - Middle Jurassic (Weynschenk 1956).

Geographical distribution: Turkey, Austrian Alps and China (Zaninetti, 1976); Western Carpathians, among other from Krížna and Choć units in the Tatra Mts. (Gaździcki, 1974, 1983; Gaździcki and Michalík, 1980); Inner Carpathians (Salaj et al., 1983); Northern Apennines (Ciarapica et al., 1987); Transdanubian Range (Oravecz-Scheffer, 1987); Lienzer Dolomiten, Osttirol, Austria (Blau and Schmidt, 1990); Bulgaria (Trifonova, 1993); Alsó Hill, Northern Hungary (Bérczi-Makk, 1996b); Karwendel range, Northern Calcareous Alps (Nittel, 2006); Urbut section, north of Izmir, Turkey (Okay and Altiner, 2007); SW Cyprus (Martini et al., 2009); Dachstein Plateau, Northern Calcareous Alps, Upper Austria and Styria (Haas et al., 2010).

In Italy, *A. sinuosus* was found in the Northern Apennines, at La Spezia (Ciarapica and Zaninetti, 1984); at Monte Cetona (Ciarapica and Zaninetti, 1985); at Verbicaro unit, Lucania and Calabria, Southern Italy (Climaco et al., 1997) and at the Northeastern Cortina d'Ampezzo - Tamarin, San Cassiano Formation, Dolomites (Di Bari and Baracca, 1998).

In the eastern Tethys (East and South East Asia): Yushu region, Qinghai, Northwest China (He and Wang, 1990); Sinta Ridge, Banda Sea, Indonesia (Villeneuve et al., 1994); Eastern Sulawesi, Indonesia (Martini et al., 1997); Seram, Indonesia (Martini et al., 2004) and Lampang Group, Northern Thailand (Kobayashi et al., 2006).

Dentalina cf. *zlambachensis* Kristan-Tollmann, 1964 (Pl. I, Fig. 28).

Section: Hlúpy (Krížna Unit; Fig. 2B).

Biostratigraphical distribution: Ladinian-Rhaetian (Trifonova, 1994).

Geographical distribution: West of Bad Aussee/Salzkammergut, Styria and Upper (Kristan-Tollmann, 1964); Transdanubian Range (Oravecz-Scheffer, 1987); Bulgaria (Trifonova, 1994).

Diplotremina ?astrofimbriata Kristan-Tollmann, 1960 (Pl. I, Fig. 11).

Section: Kominiarski Wierch (High-Tatric Unit; Fig. 4A).

Biostratigraphical distribution: Anisian (Premoli Silva, 1971) - Norian (Salaj et al. 1983).

Geographical distribution: 'Cassianer Schichten' of Eastern Alps (Kristan-Tollmann, 1960); Trento, Northern Italy (Premoli Silva, 1971); West Carpathians (Salaj et al., 1983); localities Kumaun and Hundes, Himalayas (Kristan-Tollmann, 1984); Central and

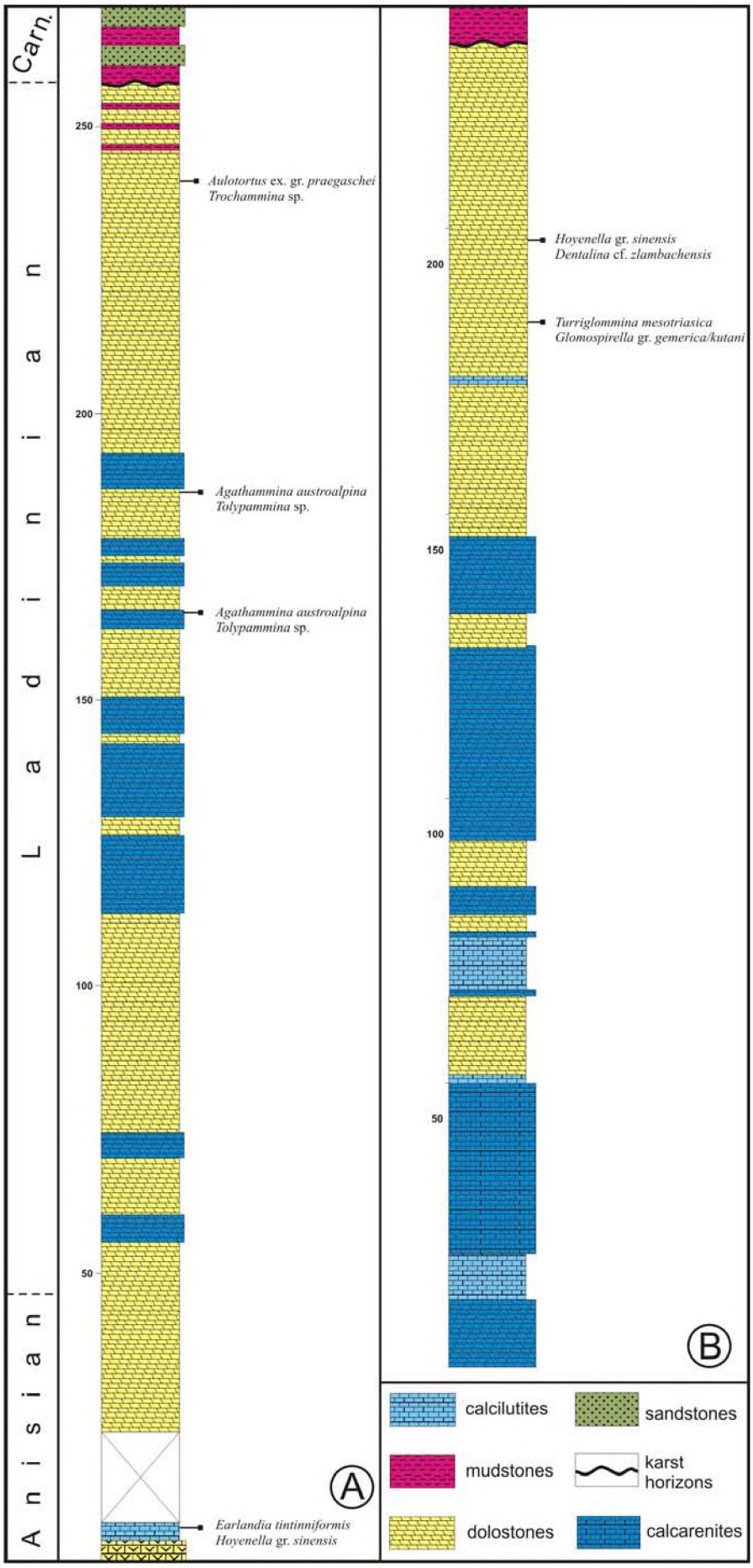

Fig. 2. *Sketch-sections of the Middle Triassic from the Krížna Unit with marked position of discovered foraminifera. a) Skupniów Uplaz section; b) Hlúpy section.*

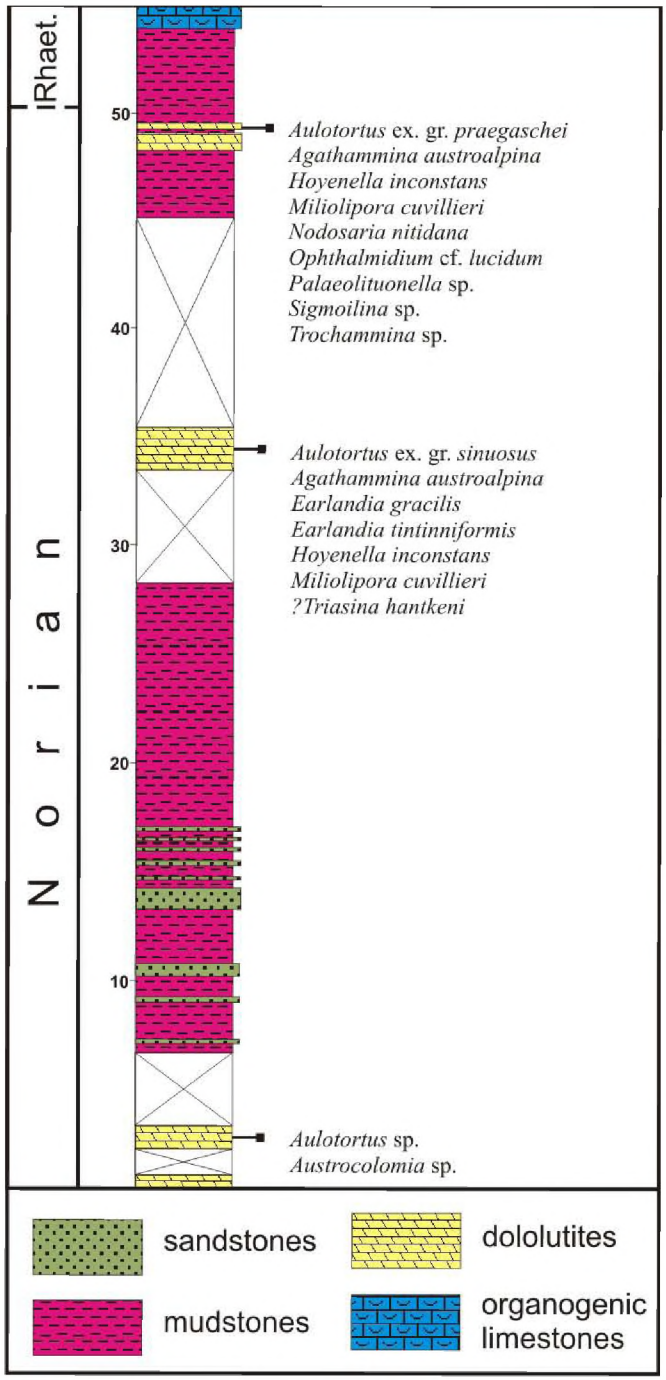

Fig. 3. *Sketch of Żleb pod Czerwoną Przełęcz section (Krížna Unit) with marked position of discovered foraminifera.*

Southern Guizhou, China (He, 1984); Transdanubian Range (Oravecz-Scheffer, 1987); Castle Hill in Bled, northwestern Slovenia (Flügel et al., 1994); Sasca Zone, Southern Carpathians, Romania (Bucur et al., 1994); Kurosegawa Terrane, Japan (Kobayashi et al, 2005); Lampang Group, Northern Thailand (Kobayashi et al., 2006); Slovenian basin, Southern Alps, Slovenia (Gale et al., 2011).

Earlandia gracilis Pantić, 1972 (Pl. I, Fig. 22).

Section: Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3).

Biostratigraphical distribution: Spathian (Trifonova, 1992) - Cordevolian (Bérczi-Makk, 1996a, b, c).

Geographical distribution: Mratinje, Montenegro (Pantić, 1972); Turkey, Austrian Alps and China (Zaninetti, 1976); West Carpathians (Salaj et al., 1983); Central Balkanides and Vlahina Mt., South West Bulgaria (Trifonova, 1992); Nádaska Limestone Formation of Alsó Hill, Nothern Hungary (Bérczi-Makk, 1996a, b, c).

Earlandia tintinniformis (Mišik, 1971) (Pl. I, Fig. 23).

Sections: Skupniów Upłaz (Krížna Unit, Fig. 2A), Żleb pod Czerwoną Przełęcz, (Krížna Unit, Fig. 3).

Biostratigraphical distribution: Early to Late Triassic (Zaninetti, 1976).

Geographical distribution: Préalpes médianes rigides, Diemtigtal, Switzerland (Zaninetti et al., 1972b); Bosnia and Herzegovina (Brönnimann et al., 1973b); Turkey, Austrian Alps and China (Zaninetti, 1976); West Carpathians (Salaj et al., 1983); Transdanubian Range (Oravecz-Scheffer, 1987); Lienzer Dolomiten, Eastern Tirol, Austria (Blau and Schmidt, 1990); Bulgaria (Trifonova, 1992); Castle Hill in Bled, Northwestern Slovenia (Flügel et al., 1994); Hydra Island, Greece (Rettori et al., 1994); Alsó Hill, Nothern Hungary (Bérczi-Makk, 1996 b); Iberian Peninsula, Spain (Arnal et al., 2002).

Glomospirella gr. *gemerica/kutani* (Salaj, 1969).

Section: Hlúpy (Krížna Unit; Fig. 2B).

Biostratigraphical distribution: Ladinian-Carnian (Salaj et al., 1983).

Geographical distribution: Slovak Karst, West Carpathian (Salaj in: Salaj, Biely and Bystrický, 1967); Turkey, Austrian Alps and China (Zaninetti, 1976); Slovakian and Polish Carpathians (Gaździcki, 1983); West Carpathians (Salaj et al., 1983); Transdanubian Central Range (Oravecz-Scheffer, 1987); Bulgaria (Trifonova, 1992); Alsó Hill, Northern Hungary (Bérczi-Makk, 1996b); Arabian shelf in the northern United Arab Emirates (Maurer et al., 2008); Southwestern Japan (Chablais et al., 2011).

Comment: Peybernès et al. (1993) determinate Glomospirellinae such as *Pilamminella (=Glomospirella ?) gemerica* (Salaj) and *P. kuthant* (Salaj) and draws attention to the fact that these closely related species often amalgamated as *Pilammmella* gr. *gemerica-kuthani*. As it is very difficult to define the specific features of these two taxa, especially with a low number of specimens, we agree with the suggestion of Peybernès et al. (1993) and Maurer et al. (2008) to attribute our few specimens to the *Glomospirella kuthani/gemeric*a group.

Glomospirella triphonensis Baud, Zaninetti and Brönnimann, 1971.

Section: Łysanki (Krížna Unit; Fig. 5C).

Biostratigraphical distribution: Olenekian-Anisian (Rettori, 1995).

Geographical distribution: Préalpes Médianes, Préalpes Romandes, Switzerland and the Chablais Préalpes, France (Baud, Zaninetti and Brönnimann, 1971); Southern Poland (Gaździcki et al., 1975); High-Tatric Unit in the Tatra Mts. (Bełka and Gaździcki, 1976); Turkey, Austrian Alps and China (Zaninetti, 1976); Jelovica river valley, Southeastern Serbia (Pantić-Prodanović and Radosević, 1977); West Carpathians (Salaj et al., 1983); Transdanubian Central Range (Oravecz-Scheffer, 1987); Bulgaria (Trifonova, 1992); North Hessen, Germany (Blau et al., 1995); Tethyan domain (Rettori, 1995); Karatash Group, Southeastern Pamir (Korchagin, 2008).

Glomospirella vulgaris Ho, 1959 (Pl. I, Fig. 5, 6).

Section: Stoły pod Ciemniakiem (High-Tatric Unit; Fig. 4B).

Biostratigraphical distribution: Smithian-Anisian (Rettori, 1995).

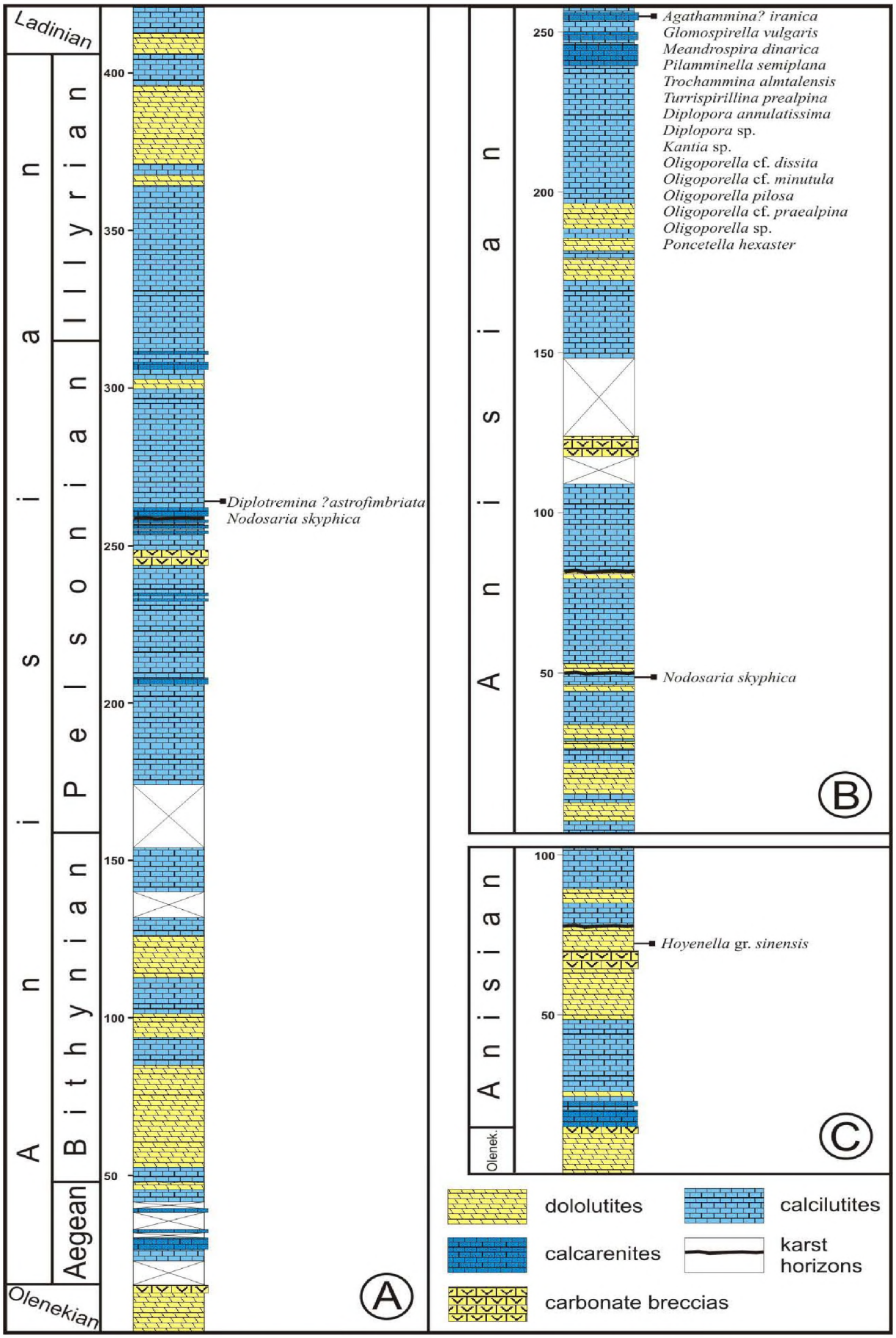

Fig. 4. *Sketch-sections of the Anisian rocks from the High-Tatric Unit with marked position of discovered microfossils. a) Kominiarski Wierch section; chronostratigraphy after Jaglarz and Szulc (2003), modified; b) Stoły pod Ciemniakiem section (section inverted in the field); c) Giewont section.*

Geographical distribution: Chialingkiang Limestone of South Szechuan, China (Ho, 1959); Northwest Caucasus and Cis-Caucasus (Efimova, 1974); Southern Poland (Gaździcki et al., 1975); Turkey, Austrian Alps and China (Zaninetti, 1976; Rettori, 1995); Bulgaria (Trifonova, 1992); countries of Sichuan and of Shaanxi, China (He, 1993); Tethyan domain (Rettori, 1995);

Comment: Rettori (1995) conducted a revision of Ho's material (Ho, 1959) and included in the synonym list of the species *Glomospirella vulgaris* the species listed as: *Ammodiscus incertus, A. semiconstrictus, A. planus, A. multivolutus, Glomospira articulosa, G. gordialis*, *G. sygmoidalis*, *Glomospirella irregularis*, *G. spirilinoides*, and *G. ammodiscoidea* as well as the species *Glomospirella irregulariformis* described as new by Efimova (1974).

Hoyenella inconstans (Michalík, Jendrejáková and Borza, 1979) (Pl. I, Figs 14, 15).

Section: Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3).

Biostratigraphical distribution: Carnian-Norian to Rhaetian (Kamoun et al., 1994).

Geographical distribution: Western Tethyan domain: Sub-Tatric (Krížna) of the Tatra Mts. (Gaździcki, 1974); West Carpathians (Salaj et al., 1983); Slovakian and Polish Carpathians (Gaździcki, 1983); Northern Apennines (Ciarapica et al., 1987); southern part of Tunisia (Peybernès et al., 1993); Tethyan realm (Rettori, 1994); Fkirine Formation, Central Tunisia (Kamoun et al., 1994); Central and Southern Tunisian Atlasic Range (Kamoun et al., 1997); Northeastern Iberian Peninsula (Arnal et al., 2002); Punta Bassano, Marettimo Island, Sicily (Martini et al., 2007).

In the eastern Tethys (East and South East Asia): Sambosan Accretionary Complex, southern Kyushu, Japan (Chablais et al., 2010a) and Southwestern Japan (Chablais et al., 2010b, 2011).

Comment: The species was introduced as *Glomospira inconstans* by Michalík, Jendrejáková and Borza in 1979. Later, Rettori (1994) referred representatives of the species: *Glomospira inflata*, *Glomospirella fatrica*, *Glomospirella minima*, and *Glomospirella paucispira* to the new genus and respectively, to the new Late Triassic combination of *Hoyenella inconstans* with *Glomospira inconstans* Michalík, Jendrejáková and Borza type species.

Hoyenella gr. *sinensis* (Ho, 1959).

Sections: Giewont (High-Tatric Unit; Fig. 4C), Żleb pod Czerwieniec (Krížna Unit; Fig. 5A), Skoruśniak (Krížna Unit; Fig. 5B), Skupniów Upłaz, Hlúpy (Krížna Unit; Fig. 2A).

Biostratigraphical distribution: Olenekian-Anisian, cosmopolitan (Rettori, 1995).

Geographical distribution: Well known from the Tethyan domain: South Szechuan, China (Ho, 1959); Dinarids and Western Carpathians (Salaj et al., 1967; Michalík et al., 1979; Salaj et al. 1983); Préalpes Romandes, Switzerland and the Chablais Préalpes, France (Baud et al., 1971); Sorkh shale formation, Tabas area, east-central Iran (Brönnimann et al., 1973c); Northwest Caucasus and Cis-Caucasus (Efimova, 1974); Southern Poland (Gaździcki et al., 1975); Kocaeli Peninsula, Western Turkey (Dager, 1978); Transdanubian Range (Oravecz-Scheffer, 1987); Internal Hellenides, Northern Greece (Baroz et al., 1990); Bulgaria (Trifonova, 1992); Weser Basin, Hesse, Northern Germany (Martini et al., 1996); Maizuru Terrane, Japan (Kobayashi, 2008).

Comment: Rettori (1994) introduced the new family Hoyenellidae, fam. n. (type-genus *Hoyenella,* gen. n.) and new *Hoyenella* genus, gen. n. (type-species: *Glomospira sinensis* Ho, 1959). The following species: *Glomospira sinensis* var. *rara* Ho, *Glomospirella facilis* Ho, *Glomospirella shengi* Ho, *Glomospirella elbursorum* Brönnimann et al., 1972; *Palaeonubecularia minuta* Brönnimann et al., 1972; *Calcitornella gebzeensis* Dager, 1978 and *Palaeonubecularia*? *floriformis* n.sp. Ciarapica and Zaninetti, 1984, the author attributed to the genus *Hoyenella*. Revision of the material type of the species *Glomospira sinensis* showed, that the porcelaneous wall and the miliolid enrollment of the test, did not allow for referring this foraminifera to the genus *Glomospira* Rzehak at least in the initial portion. Rettori (1994) unified these species in one "group" and named it *Hoyenella* gr. *sinensis* (Ho).

Meandrospira dinarica Kochansky-Devidé and Pantić, 1966 (Pl. I, Figs 12, 13).

Section: Stoły pod Ciemniakiem (High-Tatric Unit; Fig. 4B).

Biostratigraphical distribution: Anisian (Rettori, 1995).

Geographical distribution: Dinarids (Pantić, 1964; Kochansky-Devidé and Pantić, 1966); Préalpes médianes rigides, Switzerland and France (Baud et al., 1971; Zaninetti et al., 1972a, b); Trento, Northern Italy (Premoli Silva, 1971); Bosnia and Herzegovina (Brönnimann et al., 1973a, b); Eastern Hellenic zone, Greece (Christodoulou and Tsaila-Monopolis, 1972); Tabas area, East-Central Iran (Brönnimann et al., 1973a); Northwest Caucasus and Cis-Caucasus (Efimova, 1974); Southern Poland (Gaździcki et al., 1975); Jelovica river valley, Southeastern Serbia (Pantić-Prodanović and Radosević, 1977); Kocaeli Peninsula, Turkey (Dager, 1978); West Carpathians (Salaj et al., 1983); Transdanubian Range (Oravecz-Scheffer, 1987); Internal Hellenides, Northern Greece (Baroz et al., 1990); Bulgaria (Trifonova, 1993); Chios Island, Greece (Muttoni and Rettori, 1993); Pusteria valley, Dolomites, NE Italy (Zaninetti et al., 1994b); Dinarids and Hellenids (Zaninetti et al., 1994a); Castle Hill in Bled, Northwestern Slovenia (Flügel et al., 1994); Sasca Zone, Southern Carpathians, Romania (Bucur et al., 1994); Eros Limestones, Hydra Island, Greece (Rettori et al., 1994); High-Tatric Unit in the Tatra Mts. (Gaździcki and Lipiec, 1995); Alsó Hill, Northern Hungary (Bérczi-Makk, 1996a); Lombardy basin, Italy (Berra et al., 2005); Karwendel range, Northern Calcareous Alps (Nittel, 2006).

In the eastern Tethys (East and South East Asia): China (Sichuan: Ho, 1959; Guizhou: He, 1984); Japan (Kaizawa Formation, Kurosegawa Terrane: Kobayashi, 1996; Tanoura Formation, Kurosegawa Terrane: Kobayshi et al., 2005; Maizuru Terrane: Kobayashi, 2008); Lampang Group, Northern Thailand (Kobayashi et al., 2006).

Miliolipora cuvillieri Brönnimann and Zaninetti in Brönnimann, Zaninetti, Bozorgnia, Dashti and Moshtaghian, 1971 (Pl. I, Fig. 10).

Section: Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3).

Biostratigraphical distribution: Carnian (Bérczi-Makk. 1996 b) to Rhaetian, characteristic for the Norian-Rhaetian interval (Chablais et al., 2010a, b).

Geographical distribution: Nayband Formation, Iran (Brönnimann et al., 1971); Sub-Tatric (Krížna) of the Tatra Mts, where it is described as *Miliolipora* sp. (Gaździcki, 1974); Turkey, Austrian Alps and China (Zaninetti, 1976); Taurus, Turkey (Zaninetti et al., 1982); West Carpathians (Salaj et al., 1983); Transdanubian Range (Oravecz-Scheffer, 1987);

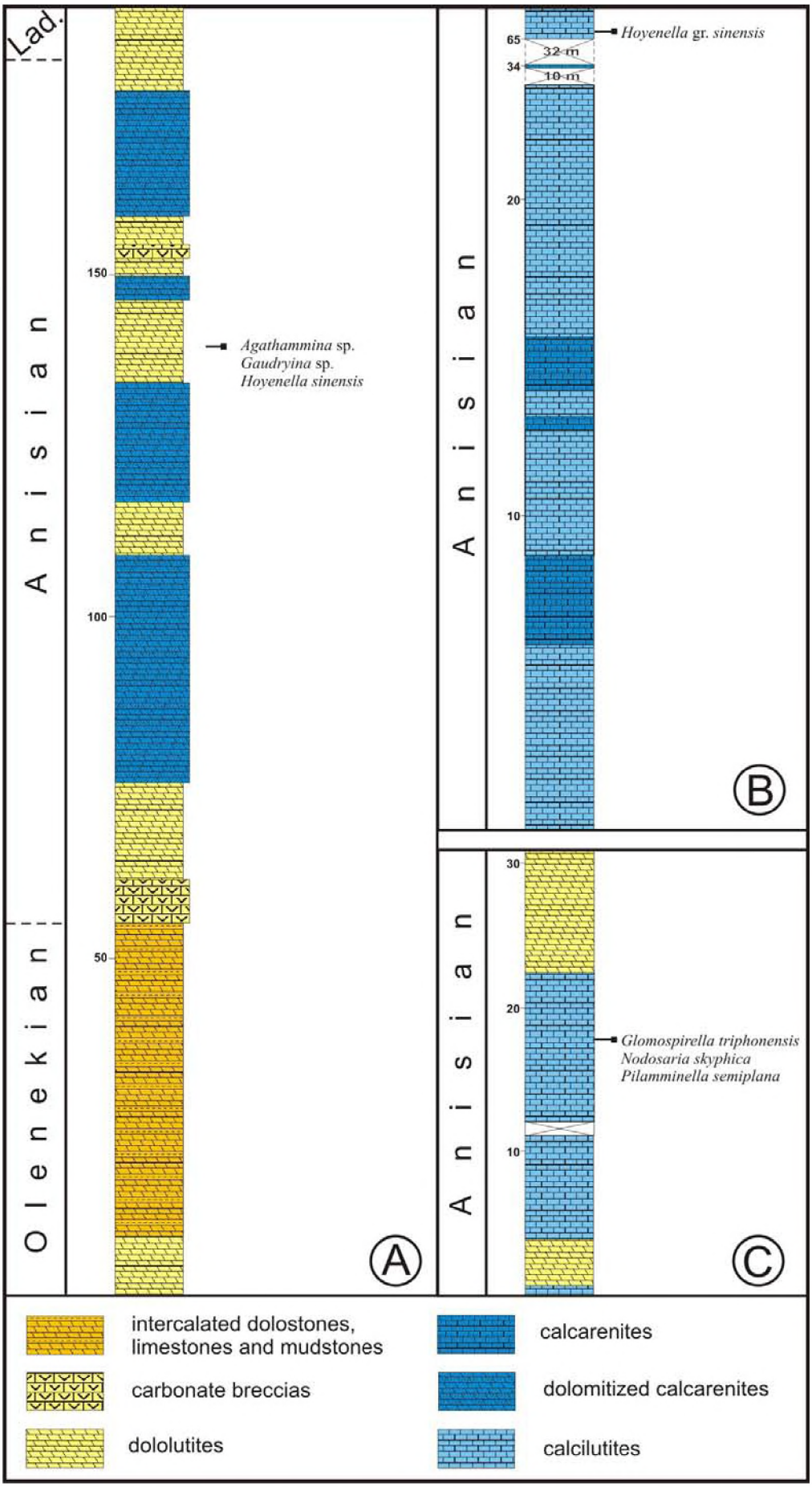

Fig. 5. *Sketch-sections of the Triassic rocks from the Krížna Unit with marked position of discovered foraminifera. a) Żleb pod Czerwieniec section; b) Skoruśniak section; c) Łysanki section.*

Bulgaria (Trifonova, 1994); Alsó Hill, Northern Hungary (Bérczi-Makk, 1996b); SW Cyprus (Martini et al., 2009); Dachstein Plateau, Northern Calcareous Alps, Upper Austria and Styria (Haas et al., 2010).

In the eastern part of the Tethyan: Banda Sea, Sinta Ridge (Villeneuve et al., 1994); Eastern Sulawesi, Indonesia (Martini et al., 1997); Sambosan Accretionary Complex, western Shikoku Island, Japan (Chablais et al., 2010a); Southwestern Japan (Chablais et al., 2010b, 2011).

Nodosaria nitidana Brand, 1937 (Pl. I, Fig. 27).

Section: Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3).

Biostratigraphical distribution: Carnian-Early Jurassic (Di Bari and Baracca, 1998).

Geographical distribution: West of Bad Aussee/Salzkammergut, Styria and Upper Austria (Kristan-Tollmann, 1964); West Carpathians (Salaj et al., 1983); Slovakian and Polish Carpathians (Gaździcki, 1983); Transdanubian Central Range (Oravecz-Scheffer, 1987); Bulgaria (Trifonova, 1994); Northeastern Cortina d'Ampezzo - Tamarin, San Cassiano Formation, Dolomites (Di Bari and Baracca, 1998).

Nodosaria skyphica Efimova, 1974 (Pl. I, Figs 25, 26).

Sections: Stoły pod Ciemniakiem, Kominiarski Wierch (High-Tatric Unit; Fig. 4A-B), Łysanki (Krížna Unit; Fig. 5C).

Biostratigraphical distribution: Late Permian-Late Triassic (Groves et al., 2005).

Geographical distribution: China (Ho, 1959; He, 1988); Northwest Caucasus and Cis-Caucasus (Efimova, 1974); Epidaurus area, Peloponnesus, Greece (Scourtsis-Coroneou et al., 1992); Bulgaria (Trifonova, 1994); Kaizawa Terrane, Japan (Kobayashi, 1996); Oravita region, Southern Carpathians, Romania (Bucur et al., 1997); Gevne Formation at the Tashkent section, Central Taurides, Turkey (Groves et al., 2005); Permian-Triassic boundary sections in Southern Alps, Northern Italy (Groves et al., 2007). The species was figured out and determined as *Nodosaria* sp. also from High-Tatric series of the Tatra Mts by Bełka and Gaździcki (1976).

Comments: Efimova (1974) introduced two new species: *Nodosaria hoi* and *Nodosaria piricamerata*. Groves et al. (2005, 2007) conducted detailed research on End-Permian mass extinction of Lagenide Foraminifera in the Southern Alps (Northern Italy) and concluded that *Nodosaria skyphica* Efimova, 1974 (=*N. hoi* skyphica Efimova, 1974) and *N. piricamerata* Efimova, 1974 are synonyms, this fact we also accept. According to the revised work of Gaillot and Vachard, 2007 species attributable to *N. hoi* should refer to the group *Polarisella* ex. gr. *hoae* (Trifonova).

Ophthalmidium cf. *lucidum* (Trifonova, 1962).

Section: Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3).

Biostratigraphical distribution: Carnian-Rhaetian (Trifonova, 1993).

Geographical distribution: East Balkan Mts., Bulgaria (Trifonova, 1993); Sub-Tatric (Krížna) of the Tatra Mts. (described and figured as *Ophthalmidium* sp.) (Gaździcki, 1974); West Carpathians (Salaj et al., 1983); Wetterstein Limestone Formation, Alsó Hill, Northern Hungary (Bérczi-Makk, 1996b).

Pilamminella semiplana (Kochansky-Devidé and Pantić, 1966) (Pl. I, Figs 7-9).

Sections: Stoły pod Ciemniakem (High-Tatric Unit; Fig. 4B), Łysanki (Krížna Unit; Fig. 5C).

Biostratigraphical distribution: Anisian-Late Triassic, most widespread in the middle-upper Anisian (Rettori, 1995).

Geographical distribution: western part of the Tethyan realm: Dinarids (Kochansky-Devide and Pantić, 1966); Almtal region, Austrian Alps (Koehn-Zaninetti, 1969); Trento, Northern Italy (Premoli Silva, 1971); Préalpes médianes rigides, Switzerland and France (Baud et al., 1971); Eastern Hellenic zone, Greece (Christodoulou and Tsaila-Monopolis, 1972); Bosnia and Herzegovina (Brönnimann et al., 1973a, b); Lower Silesia in Poland (Głazek et al., 1973); Northwest Caucasus and Cis-Caucasus (Efimova, 1974); Southern Poland (Gaździcki et al., 1975); Tatra Mts. in Poland (Bełka and Gaździcki, 1976); Turkey, Austrian Alps and China (Zaninetti, 1976); Jelovica river valley, Southeastern Serbia (Pantić-Prodanović and Radosević, 1977); Kocaeli Peninsula, Turkey (Dager, 1978); West Carpathians (Salaj et al., 1983); Transdanubian Range (Oravecz-Scheffer, 1987); Bulgaria (Trifonova, 1992); Chios Island, Greece (Muttoni and Rettori, 1993); Dolomites, North-east Italy (Zaninetti et al., 1994b); Dinarids and Hellenids (Zaninetti et al., 1994a); Sasca Zone, Southern Carpathians, Romania (Bucur et al., 1994); Eros Limestones, Hydra Island (Rettori et al., 1994); Tethyan region (Rettori, 1995); Nordhessen, Germany (Blau et al., 1995); Weser Basin in Hesse, Northern Germany (Martini et al., 1996); Alsó Hill, Northern Hungary (Bréczi-Makk, 1996); Southern Carpathians, Rumania (Bucur et al., 1997); Lombardy basin, Italy (Berra et al., 2005); Karwendel range, Northern Calcareous Alps (Nittel, 2006).

In the East and South East Asia: China (Sichuan: Ho, 1959; Guizhou: He, 1984; Yushu region, Qinghai: He and Wang, 1990) and Japan (Kobayashi, 1996, 2008; Kobayshi et al., 2005; and Maizuru Terrane of the Yakuno area, Kyoto Prefecture: Kobayshi, 2008).

Comment: According the revision made by Rettori (1995) of the both species and in agreement with the law of priority of ICZN, the species *Pilammina grandis* Salaj, in Salaj, Biely and Bystrický, 1967) is a junior synonym of the species *Pilammina semiplana* (Kochansky-Devidé and Pantić, 1966).

?*Triasina hantkeni* Majzon, 1954, emend. Koehn-Zaninetti, 1968 (Pl. I, Fig. 30).

Section: Żleb pod Czerwoną Przełęcz (Krížna Unit; Fig. 3).

Biostratigraphical distribution: Norian (Sevatian)-Rhaetian, cosmopolitan (Di Bari and Rettori, 1996).

Geographical distribution: Yugoslavian Inner Dinarids (Pantić and Rampnoux, 1972); Eastern Hellenic Zone (Christodoulou and Tsaila-Monopolis, 1972); Upper Sub-Tatric (Choč) of the Western Carpathian, among other the Tatra Mts. (Gaździcki and Zawidzka, 1973; Gaździcki and Michalík, 1980; Gaździcki, 1983); Lower Sub-Tatric (Krížna) of the Western Carpathian, among other the Tatra Mts. (Gaździcki, 1974, 1983); Taurus Mts, Turkey (Dager, 1975); Europe and Asia (Al-Shaibani et al., 1982); West Carpathians (Salaj et al., 1983); Northern Apennines (Ciarapica et al. 1987); Transdanubian Range (Oravecz-Scheffer, 1987); Wombat plateau, Northwest Australia (Zaninetti et al., 1992); Sella Group Piz Boé, Western Dolomites, Italy (Di Bari and Rettori, 1996); Central and Southern Tunisian Atlasic Range (Kamoun et al., 1997); Verbicaro Unit, Lucania and Calabria, Southern Italy (Climaco et al., 1997); Cetmi Melange, northwest

Turkey (Beccaletto et al., 2005); North of Izmir, Turkey (Okay and Altiner, 2007) and other. Arabian shelf in the northern United Arab Emirates (Maurer et al., 2008); Norian of Dachstein Plateau, Northern Calcareous Alps, Upper Austria and Styria (Haas et al., 2010).

In eastern part of the Tethyan domain: Yushu region, Qinghai, Northwest China (He and Wang, 1990); Eastern Sulawesi, Indonesia (Martini et al., 1997); Seram, Indonesia (Martini et al., 2004); Sambosan Accretionary Complex, southern Kyushu, Japan (Chablais et al., 2010a).

Trochammina almtalensis Koehn-Zaninetti, 1969 (Pl. I, Figs 19-20).

Section: Stoły pod Ciemniakiem (High-Tatric Unit; Fig. 4B);

Biostratigraphical distribution: Anisian-Carnian (Bérczi-Makk, 1996a, b).

Geographical distribution: Almtal region, Austrian Alps (Koehn-Zaninetti, 1969); Trento, Northern Italy (Premoli Silva, 1971); Préalpes médianes rigides (Préalpes Romandes, Switzerland and the Chablais Préalpes, France) (Baud et al., 1971); Bosnia and Herzegovina (Brönnimann et al., 1973a, b); Choč nappe from the Tatra Mts. (Gaździcki and Zawidzka, 1973); Southern Poland (Gaździcki et al., 1975); Turkey, Austrian Alps and China (Zaninetti, 1976); West Carpathians (Salaj et al., 1983); Central and Southern Guizhou, China (He, 1984); Qinghai, Northewestern China (He and Wang, 1990); Oravita, Southern Carpathians, Romania (Bucur et al., 1997); Transdanubian Range (Oravecz-Scheffer, 1987); Bulgaria (Trifonova, 1992); Alsó Hill, Northern Hungary (Bérczi-Makk, 1996a, b).

Turriglommina mesotriasica (Kohen-Zaninetti, 1969) (Pl. I, Fig. 24).

Section: Hlúpy (Krížna Unit; Fig. 2B).

Biostratigraphical distribution: Early? Anisian-Carnian (Rettori, 1995), most often cited within the upper Anisian-Ladinian interval (Bucur et al., 1997).

Geographical distribution: Almtal region, Austrian Alps (Koehn-Zaninetti, 1969); Trento, Northern Italy (Premoli Silva, 1971); Choč nappe of the Tatra Mts., Poland (Gaździcki and Zawidzka, 1973); Caucasus (Efimova, 1974); Turkey, Austrian Alps and China (Zaninetti, 1976); Turkey (Dager, 1978); West Carpathian (Salaj et al., 1983); China (He, 1984; He and Cai, 1991); Transdanubian Range (Oravecz-Scheffer, 1987); Bulgaria (Trifonova, 1993); Eros Limestones, Hydra Island, Greece (Rettori et al., 1994); Tethyan domain (Rettori, 1995); NE of Oravita, Southern Carpathianhs, Rumania (Bucur et al., 1997); Karwendel range, Northern Calcareous Alps (Nittel, 2006); Arabian shelf in the northern United Arab Emirates (Maurer et al., 2008).

Turrispirillina prealpina Zaninetti and Boennimann in Zaninetti, Brönnimann and Baud, 1972b (Pl. I, Fig. 29).

Section: Stoły pod Ciemniakiem (High-Tatric Unit; Fig. 4B).

Biostratigraphical distribution: Late Anisian-Norian (Rettori, 1995).

Geographical distribution: Préalpes médianes rigides, Switzerland and France (Zaninetti et al., 1972a, b); West Carpathians (Salaj et al., 1983); Bulgaria (Trifonova, 1993); Eros Limestones, Hydra Island, Greece (Rettori et al., 1994); Tethyan realm (Rettori, 1995).

In addition to described species, some other were determined: *Agathamina* sp., *Gaudryina* sp. (Żleb pod Czerwieniec section; Fig. 5A), *Trochammina* sp., *Tolypammina* sp. (Skupniów Upłaz section; Fig. 2A), as well *Aulotortus* sp., *Austrocolomia* sp., *Sigmoilina* sp., *Trochammina* sp. and *Palaeolituonella* sp. from the Żleb pod Czerwoną Przełęcz section (Fig. 3).

Calcareous algae

In one sample from the High-Tatric Unit, rich assemblage of green algae there were present, comprising the following taxa (*see* Plate II):

cf. *Diplopora annulatissima* Pia, 1920
Diplopora sp.
Kantia sp.
Oligoporella cf. *dissita* (Gümbel, 1872) Grgasović 1995
Oligoporella cf. *minutula* (Gümbel, 1872) Grgasović 1995
Oligoporella pilosa Pia, 1912, var. *pilosa* Pia ex Bystrický 1964
Oligoporella cf. *praealpina* Pia, 1920
Oligoporella sp.
Poncetella hexaster (Pia, 1912) Güvenć, 1979.

Section: Stoły pod Ciemniakiem (High-Tatric Unit; Fig4. B)

Biostratigraphical and geographical distribution: The assemblage containing species: *Oligoporella dissita, O. minutula, O. pilosa, O. praealpina* and *Poncetella hexaster* is very well known from Anisian deposits with a maximum in Pelsonian-Lower Illyrian. This algae association was found in Europe only: Austria (Gümbel, 1872), Bosnia-Herzegovina (Pia, 1935; Herak, 1965), Bulgaria (Kotański and Čatalov, 1973), Croatia (Pia, 1912; 1920; 1925; Herak, 1965), Switzerland (Botteron, 1961), Greece (Herak, 1967), Italy (Senowbari-Daryan et al., 1993; Bassi and Fugagnoli, 2005), Poland (Kotański, 1986), Romania (Diaconu and Dragastan, 1969; Patrulius, 1970; Bleahu et al., 1972; Popa and Dragastan (1973); Dragastan and Grădinaru (1975); Dragastan et al., 1981; Strutinski et al., 1987; Bucur et al., 1994; Bucur, 1997), Slovakia (Pia, 1940; Bystrický, 1957; 1964; 1966; 1986; Flügel, 1982; Buček, 1989), Serbia (Pia, 1912; 1925; Herak, 1965; Pantić, 1970), Slovenia (Flügel et al., 1994), and Hungary (Budai et al., 1993, Piros, 2002).

A very interesting element of the assemblage consists of the probably presence of *Diplopora annulatissima*. This species was found in the same area as the previously mentioned assemblage, but also in Sicily (Senowbari-Daryan and Di Stefano, 2001), in Spain (Braga and Martin, 1987), and also in China (Bucur and Enos, 2001), the last occurrence belonging to the Eastern Asia palaeogeographical province. The presence of *D. annulatissima* could also have a biostratigraphical importance. The species is mainly known from Upper Anisian (Illyrian). Grgasović and Sokač (2003) mention that rare specimens of this species are also present in the Upper Pelsonian.

STRATIGRAPHIC CONSIDERATIONS

High-Tatric Unit

Many of the identified benthic foraminifera species have a relatively large stratigraphical range, covering almost all Triassic stages. However, some species are restricted to specific time intervals. The association recognized in sample from the upper part of the Stoły pod Ciemniakiem section, represented by a very characteristic *Meandrospira dinarica* (Pelsonian-Lower Illyrian) and *Pilamminella semiplana* species is undoubtedly of Anisian age, based on the occurrences of two index species for Anisian in Europe and in middle eastern Asia as well.

Considering the whole assemblage containing calcareous algae *Oligoporella* species, characteristic for the *Oligoporella pilosa-Physoporella pauciforata* zone of Bystrický (1986), as well as presence of the foraminifera *Meandrospira dinarica*, and *Diplopora annulatissima,* which are characteristic for the Illyrian, the most probable age of the studied samples from the Stoły pod Ciemniakiem section is Lower Illyrian.

Krížna Unit

Numerous sections of the foraminifera species (*Pilamminella semiplana* (Kochansky-Devidéand Pantić), *Glomospirella triphonensis* Baud, Zaninetti and Broennimann and *Nodosaria skyphica* Efimova, from the limestones of the Łysanki section, as well as *Hoyenella* gr. *sinensis* (Ho), *Agathammina* sp. and *Gaudryina* sp. from Żleb pod Czerwieniec and Skoruśniak sections) undoubtedly indicate Anisian age of the studied Krížna Unit deposits. Identified foraminifera suggest probably early Anisian age due to the absence of index species of the Middle and Late Anisian (Pelsonian-Illyrian) *Pilammina densa* Pantić.

The dolostones of the Skupniów Upłaz and Hlúpy sections (Krížna Unit) comprise some characteristic foraminifera genera and species, which indicated the Ladinian age. The typical species for this time interval are: *Turriglommina mesotriasica* (Koehn-Zaninetti), *Glomospirella* gr. *gemerica/kutani* (Salaj), *Aulotortus* ex. gr. *praegaschei* (Koehn-Zaninetti, *Trochammina cf. almtalensis* Koehn-Zaninetti, *Dentalina* cf. *zlambachensis* Kristan-Tollmann, *Agathammina* cf. *austroalpina* Kristan-Tollmann and Tollman and *Tolypammina* sp. A Ladinian age is indicated by the *Turriglomina mesotriasica - Glomospirella kuthani/gemerica - Aulotortus gaschei praegaschei* assemblage presented in the dolostones of the Skupniów Upłaz and Hlúpy sections. The most representative species of this assemblage is *T. mesotriasica* in association with ovoid to spherical large Ammodiscidae referable to *Glomospirella kuthani/gemerica* which is of Ladinian–Carnian age. The presence of rare but very characteristic *T. mesotriasica* (Koehn-Zaninetti) together with species *Glomospirella* aff. gr. *gemerica/kutani* (Salaj, *Aulotortus* ex. gr. *praegaschei* (Koehn-Zaninetti, *Dentalina* cf. *zlambachensis* Kristan-Tollmann, *Agathammina austroalpina* Kristan-Tollmann and Tollman, *Trochammina* sp. and *Tolypammina* sp. allows to refer this assemblage to the Ladinian, before the radiation and diversification of the Involutinidae family.

Dolostones of the Żleb pod Czerwoną Przełęcz section (Krížna Unit) comprise species which indicate Upper Norian-Rhaetian. The assemblage includes ?*Triasina hantkeni* Majzon which is the zone marker for many Upper Triassic successions. *Triasina hantkeni* range zone was first introduced by Salaj (1969) for the Rhaetian deposits of Western Carpathians. Salaj et al. (1988) redescribed the zone with the latest Sevatian-Rhaetian range. The Late Norian (Sevatian) to Rhaetian age was corroborated by the occurrence of the ?*Triasina hantkeni* zone marker in many Upper Triassic successions, like in the *Raetavicula contorta* beds in the Northern Apennines (Ciarapica et al., 1987) and in the Briançonnais Domain in the Western Alps and in the Préalpes Médianes (Zaninetti et al., 1986). Other accompanying foraminifera in this zone are: *Miliolipora cuvillieri* Broennimann and Zaninetti, *Aulotortus* ex. gr. ?*sinuosus* Weynschenk, *Hoyenella inconstans* (Michalík, Jendrejáková and Borza), *Agathammina austroalpina* Kristan-Tollmann and Tollman, *Ophthalmidium* cf. *lucidum* (Trifonova), *Nodosaria nitidana* Brand**,** *Earlandia gracilis* Pantic, *E. tintinniformis* (Mišik), *Sigmoilina* sp., *Trochammina sp., Palaeolituonella* sp. and *Austrocolomia* sp.

FINAL REMARKS

Most of recognized taxa of benthic foraminifera and calcareous algae are described for the first time from the Anisian-Norian succession of High-Tatric and Krížna units in the Tatras. Unfortunatelly, only part of them belong to index fossils. Nevertheless, the horizons with index fossils can be useful as stratigraphic markers in the case of the High-Tatric Unit.

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Plate 1. Determined foraminifera from High-Tatric and Krížna units (Anisian-Norian) (Scale bar: A – x 80; B – x160).

Fig. 1. *Aulotortus* ex.gr. ?*sinuosus* Weynschenk, 1956 (Żleb pod Czerwoną Przełęcz, Krížna Unit, x80).

Figs 2-4. *Aulotortus* ex. gr. *praegaschei* (Koehn-Zaninetti, 1969) (2 - Skupniów Upłaz, Krížna Unit, x80; 3, 4 - Żleb pod Czerwoną Przełęcz, Krížna Unit, x80).

Figs 5-6. *Glomospirella vulgaris* Ho, 1959 (Stoły pod Ciemniakiem, High-Tatric Unit, x80).

Figs 7-9. *Pilamminella semiplana* (Kochansky-Devide & Pantić, 1966) (Stoły pod Ciemniakem, High-Tatric Unit, x80).

Fig. 10. *Miliolipora cuvillieri* Brönnimann & Zaninetti in Brönnimann, Zaninetti, Bozorgnia, Dashti & Moshtaghian, 1971 (Żleb pod Czerwoną Przełęcz, Krížna Unit, x80).

Fig. 11. *Diplotremina* ?*astrofimbriata* Kristan-Tollmann, 1960 (Kominiarski Wierch, High-Tatric Unit, x160).

Figs 12-13. *Meandrospira dinarica* Kochansky-Devidé & Pantić, 1966 (Stoły pod Ciemniakiem, High-Tatric Unit, x160).

Figs 14-15. *Hoyenella inconstans* (Michalík, Jendrejáková & Borza, 1979) (Żleb pod Czerwoną Przełęcz, Krížna Unit, x160).

Fig. 16. *Agathammina? iranica* Zaninetti, Brönnimann, Bozorgnia & Huber, 1972c (Stoły pod Ciemniakiem, High-Tatric Unit, x160).

Figs 17-18. *Agathammina austroalpina* Kristan-Tollmann & Tollman, 1963 (Skupniów Upłaz, Żleb pod Czerwoną Przełęcz, Krížna Unit, x160).

Figs 19-20. *Trochammina almtalensis* Koehn-Zaninetti, 1969 (19 - Stoły pod Ciemniakiem, HighTatric Unit); (20 - Skupniów Upłaz, Krížna Unit, x160).

Fig. 21. Undetermined foraminifer (Żleb pod Czerwieniec, Krížna Unit, x160).

Fig. 22. *Earlandia gracilis* Pantić, 1972 (Żleb pod Czerwoną Przełęcz, Krížna Unit, x80).

Fig. 23. *Earlandia tintinniformis* (Mišik, 1971) (Żleb pod Czerwoną Przełęcz, Skupniów Upłaz, Krížna Unit, x160).

Fig. 24. *Turriglommina mesotriasica* (Kohen-Zaninetti, 1969) (Hlúpy, Krížna Unit, x160).

Figs 25-26. *Nodosaria skyphica* Efimova, 1974 (Stoły pod Ciemniakiem, Kominiarski Wierch, High-Tatric Unit, x160).

Fig. 27. *Nodosaria nitidana* Brand, 1937 (Żleb pod Czerwoną Przełęcz, Krížna Unit, x160).

Fig. 28. *Dentalina* cf. *zlambachensis* Kristan-Tollmann, 1964 (Hlúpy, Krížna Unit, x160).

Fig. 29. *Turrispirillina prealpina* Zaninetti & Boennimann in Zaninetti, Brönnimann & Baud, 1972b (Stoły pod Ciemniakiem, High-Tatric Unit, x160).

Fig. 30. ?*Triasina hantkeni* Majzon, 1954, emend. Koehn-Zaninetti, 1968 (Żleb pod Czerwoną Przełęcz, Krížna Unit, x80).

PLATE I

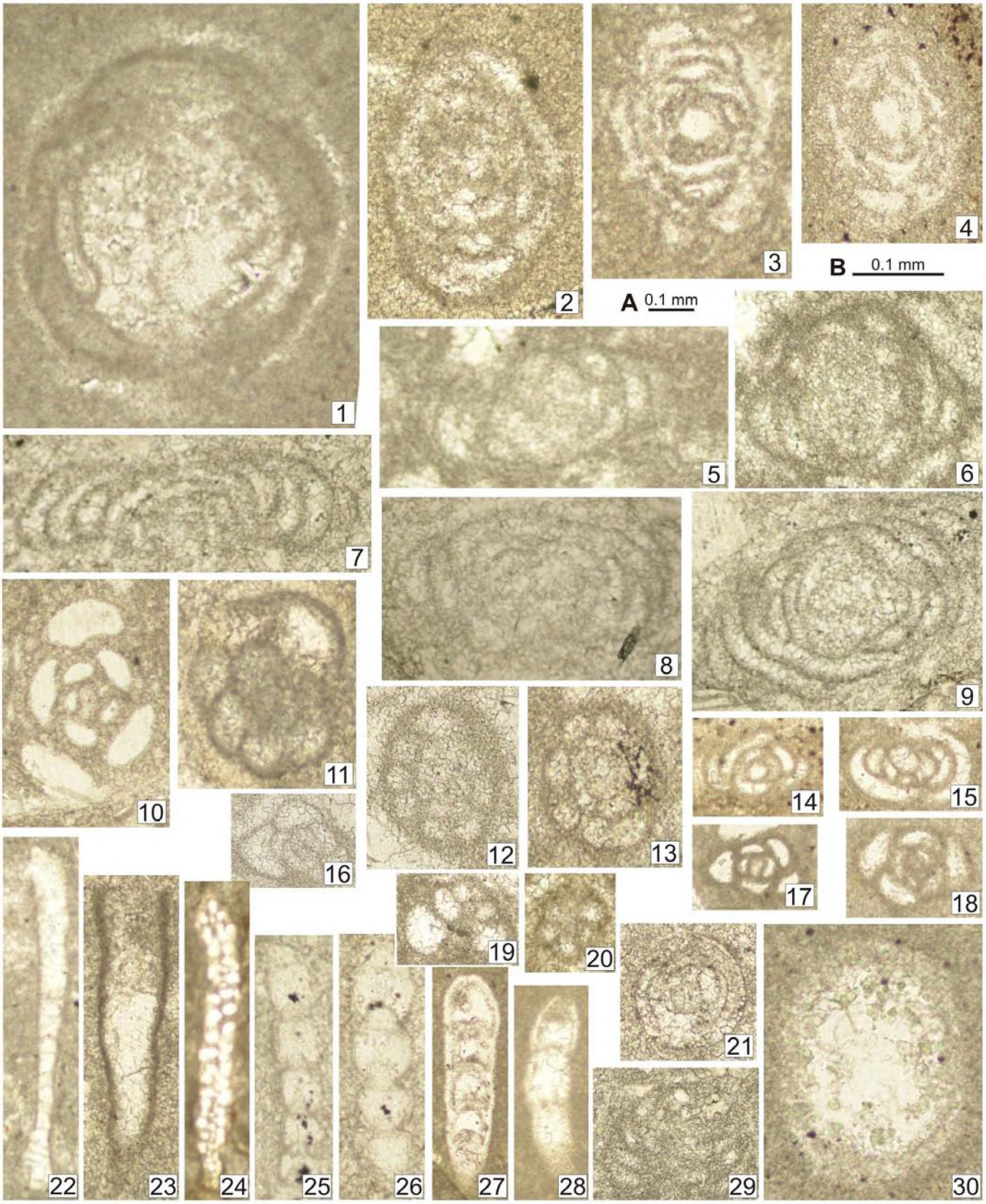
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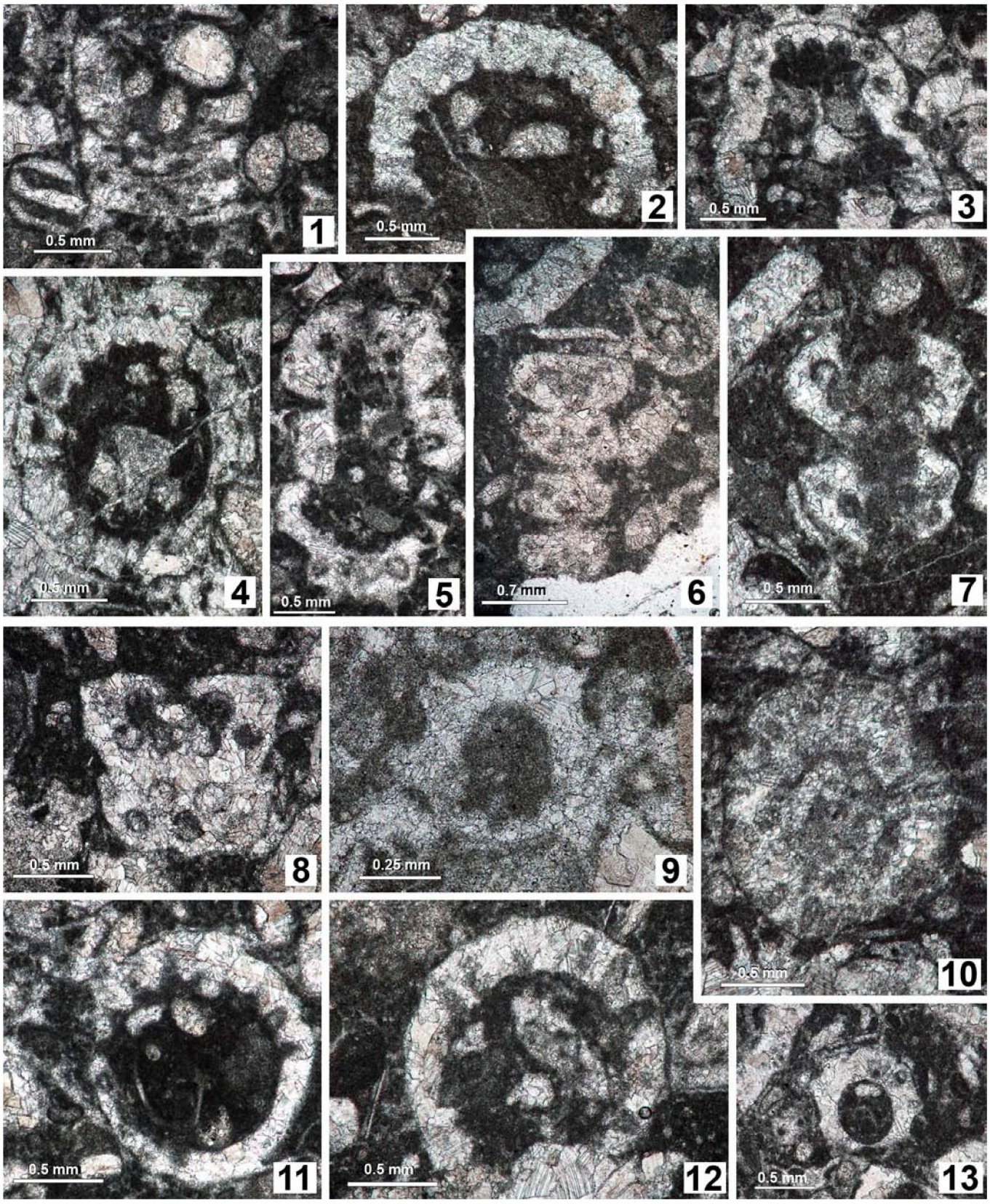
Plate 2. Determined calcareous algae from the Stoły pod Ciemniakiem section (High-Tatric Unit; see Fig. 4B).

Fig. 1. cf. *Diplopora annulatissima* PIA. Oblique section.
Fig. 2. *Diplopora* sp. Transverse section.
Fig. 3. *Oligoporella* cf. *praealpina* PIA. Oblique section.
Fig. 4. *Kantia* sp. Transverse section.
Fig. 5. *Oligoporella* sp. Oblique section.
Figs 6-8. *Oligoporella* cf. *dissita* (Gümbel). 6 – oblique-tangential (left) and transverse (upper right) sections; 7 – longitudinal-oblique section; 8 – tangential-oblique section.
Fig. 9. *Oligoporella* cf. *minutula* (Gümbel). Transverse section.
Fig. 10. *Poncetella hexaster* (Pia). Transverse section.
Figs 11-12. *Oligoporella pilosa pilosa* Pia. Transverse sections.
Fig. 13. *Oligoporella* sp. Transverse section.

PLATE II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